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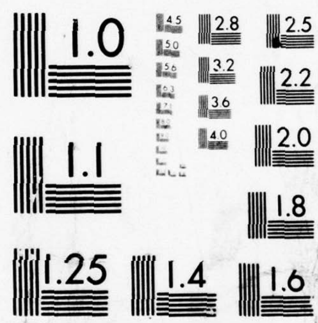

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AIR FORCE

HUMAN RESOURCES

IMPACT OF LEARNING STYLES ON AIR FORCE TECHNICAL TRAINING:

MULTIPLE AND LINEAR IMAGERY IN THE PRESENTATION OF A COMPARATIVE VISUAL LOCATION TASK TO VISUAL AND HAPTIC SUBJECTS

By

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LABORATORY

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NOTICE

This interim report was prepared by the University of Oklahoma, College of Education, Norman, Oklahoma 73019 under contract F33615-77-C-0047, project 2313, with Technical Training Division, Air Force Human Resources Laboratory (AFSC), Lowry Air Force Base, Colorado 80230. Dr. James R. Burkett was the Contract Monitor for the Laboratory.

This technical report has been reviewed and is approved for publication.

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Technical Training Division

RONALD W. TERRY, Colonel, USAF
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The study reported herein is basic research which may be of interest only to a limited audience.

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18. SUPPLEMENTARY NOTES

The study reported herein is basic research which may be of interest only to a limited audience.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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learning styles	visual-haptic styles

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to develop instruction based on the supplantation theory, in which tasks are performed (supplanted) for individuals that are unable to perform them due to their cognitive style. Results of this study indicate that in the particular learning situation in this investigation, the haptic cognitive style individual's performance was improved by instruction based on the supplantation theory. The results of this preliminary investigation seem to hold promise for instructional research with Air Force technical training personnel.

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INTRODUCTION

Background

An examination of research literature on cognitive styles (Ausburn, L.J., 1976) indicates that there is a relationship between an individual's manner of acquiring and processing information and his or her performance on some learning tasks. Cognitive style as a learner characteristic appears to interact unfavorably with the psychological requirements of some tasks and thus to result in poor performance by the learner. A reason for this phenomenon can be postulated by conceptualizing the relationship between learner characteristics and task requirements as a corridor or "link," as illustrated in Figure 1.

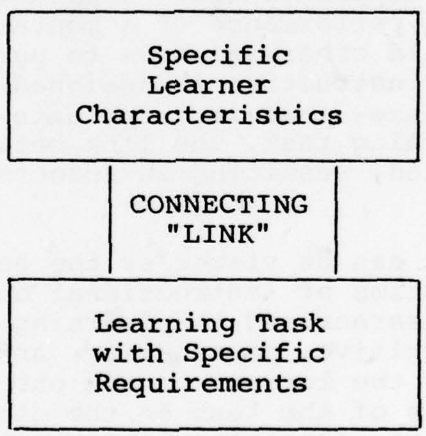

Figure 1.
Learner/Task Link

This "link" can be viewed as the connection between learner and task. The task requirements define what is <u>necessary</u> in order to perform successfully; the learner characteristics influence, on the other hand, what the learner is <u>capable</u> of performing. In cases where task requirements and learner's capabilities dictated by his or her cognitive style are compatible, the link between task and learner is easily completed, and performance on the task is likely to be satisfactory. If, however, there is a discrepancy between task requirements and learner capabilities, the line is incomplete, and performance is likely to be poor. It is in these cases that a negative relationship between cognitive style and task performance could be expected to be demonstrated.

One approach to dealing with unfavorable cognitive style/learning task interactions would be to alter the cognitive style which is giving trouble. Research has indicated, however (Elliott & McMichael, 1963; Kagan, Pearson, & Welch, 1966; Yando & Kagan, 1968; Debus, 1970), that cognitive style is quite resistant to change. The only successful results in altering it, which could be located by the author, were short-term reductions in field-dependence as measured by the Rod and Frame Test (Wolf, 1965; Jacobson, 1966, 1968). In view of this apparent resistance of cognitive style to long-term and generalizable change, it would appear that designing instruction to minimize gaps in the links between learner capabilities and task requirements is likely to be more productive than trying to alter learners' cognitive style characterisitcs.

The approach to designing instruction intended to bridge gaps in the learner/task link which forms the basis of the present study is based on a process which Salomon (1970) has called <u>supplantation</u>. Supplantation is the explicit and overt performance of a mental task requirement which learners would otherwise have to perform covertly for themselves. When instruction is designed so that it performs for learners--that is, supplants--the functions required by a learning task, the link between task and learner is completed, resulting in success by the learner on that task.

Supplantation can be viewed as the heart of the psychological function of instructional design. It deals with linking the learner and the learning task, a link which is tied to the cognitive, personality, and intellectual characteristics of the learner on the one hand and to the mental requirements of the task on the other. The function of supplantation, as illustrated in the model shown in Figure 2, is to create a "bridge" which fills gaps that exist in the link between these two. The supplantation "bridge" is constructed through a carefully designed instructional treatment which interacts with both learner characteristics and task requirements, performing for the learners that which they are unable to do themselves but is demanded for successful performance of the task at hand.

In utilizing a supplantation approach to instructional design, there would appear to be three basic questions which must be dealt with:

(1) What basic mental function is required in order to perform satisfactorily on a given learning task?

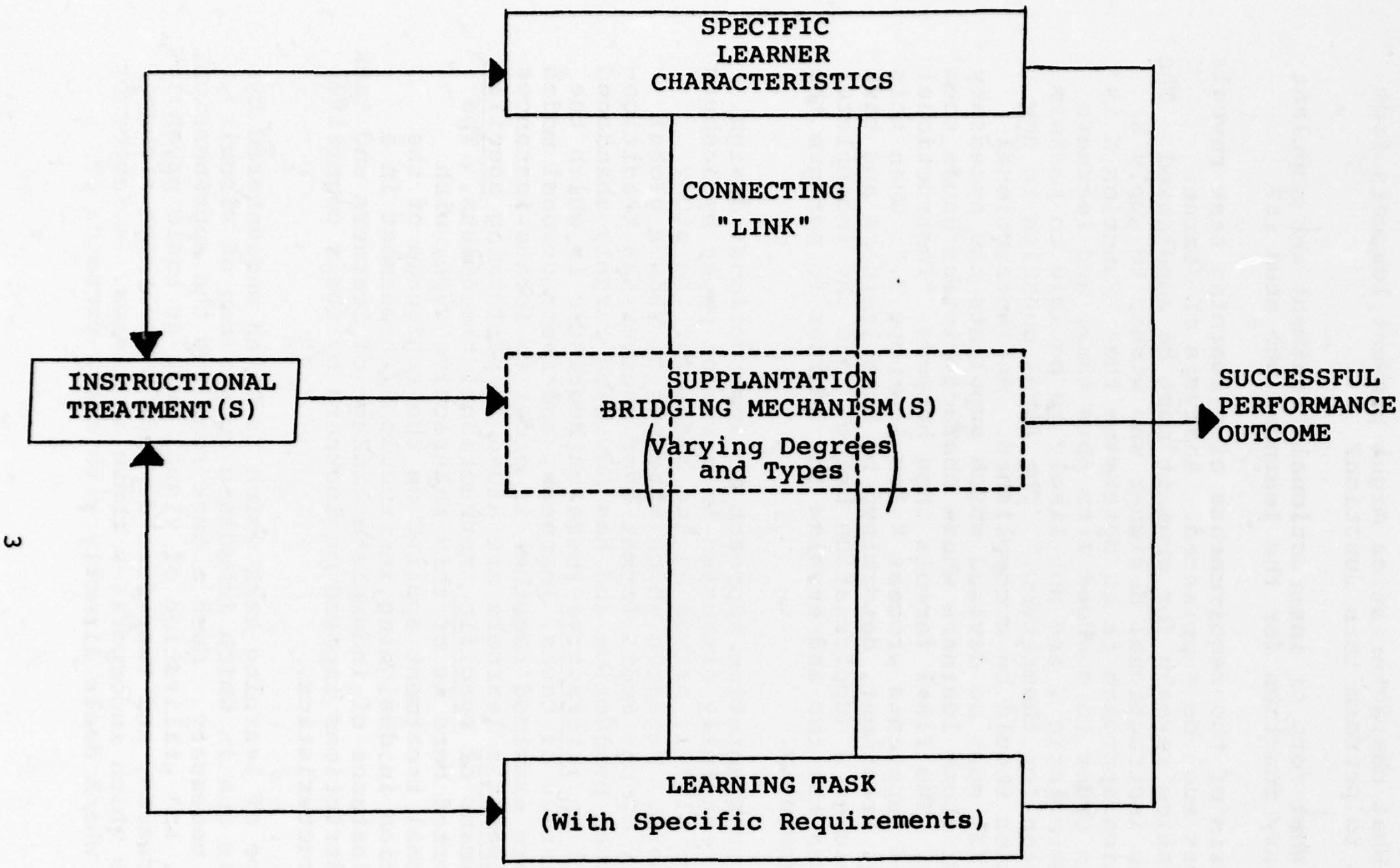

Figure 2. SUPPLANTATION MODEL FOR INSTRUCTIONAL DESIGN

(2) What characteristics might prevent learners from being able to perform this function?

(3) What form of instructional treatment can supplant the necessary function for the learners who need it?

Analysis of the requirements of a learning task reveals what process must be supplanted. Analysis of learner characteristics reveals for whom it must be supplanted. The goal of the instructional designer who wishes to apply a supplantation approach is to determine that "Function X is required in order to succeed with this task, and learners with characteristic Y are not likely to be able to perform this function for themselves." The final question is how supplantation should be accomplished. An instructional treatment (Z) must be devised which supplants the necessary process for those learners whose characteristics cause them to need it. The final formula then becomes, "Instructional treatment Z supplants process X for learners Y." When this occurs, the treatment, determined by both learners and task factors, places a supplantation bridge into the incomplete link between the two and enables the learner to perform the task successfully.

This supplantation approach to instructional design, which has been fully discussed in a recent paper by Ausburn and Ausburn (1977), serves as the basis for the study reported here. Research which attempts to show a global superiority of one media format over another has traditionally not been productive and has now been largely abandoned in favor of an interactive research heuristic in which the characteristics of tasks, learners, and instructional modes or media are examined together in order to locate instances in which specific learners are aided in performing specific tasks by means of specific instructional treatments. The study reported here is of this interactive type, with instructional treatment applied on the rationale of the supplantation in designing instructional treatment in a specific instance of incomplete linkage of learners and task due to restrictions imposed on learners by their cognitive style characteristics.

A type of learning task which is often encountered by students is one in which immediate comparison of visual images is necessary. Such a task requires the apprehension, retention, and utilization of visual cues as basic psychological processes, and therefore demands of learners a cognitive style which incorporates these abilities. A factor or dimension which deals directly with their presence or absence is the perceptual typology developed by Viktor Lowenfeld. In extensive research, Lowenfeld (1945, 1957) identified two distinct types of individuals with two distinctly different styles of perception. He called these two distinct types the visual type and the haptic type.

The visual type was defined by Lowenfeld (1957) as a person who reacts to his environment as a spectator and whose main sensory intermediaries are his or her eyes. The haptic individual was defined as a normally sighted person who reacts to his or her environment subjectively and who uses his or her eyes as primary sensory intermediaries only when compelled to do so, preferring to rely on muscular sensations, kinesthetic experiences, and tactile impressions.

One of the principal distinctions between visuals and haptics is that while visuals can mentally retain visual images, haptics cannot (Lowenfeld, 1945). This suggests that haptic individuals, established by Lowenfeld (1945) to represent almost one-fourth of the population, could be expected to encounter difficulty with learning tasks requiring comparison of visual images if such tasks are presented in such a way as to require the mental retention of images for comparison. Visual comparison tasks form a relatively common type of learning task (often encountered in learning to operate equipment, in comparing physical properties and functions of items, in locating the placement of specific items relative to others, etc.), which may present difficulty to approximately one-fourth of any student population due to cognitive style limitations. Therefore, a visual comparison task was selected as the interacting task and haptic style was selected as the learner characteristic for study in this attempt to apply supplantational instructional design.

Having selected a task requirement/learner characteristic pair for study (i.e., the "what" and the "for whom" of the supplantation approach to instructional design), it remained to hypothesize an appropriate instructional treatment (the "how") designed to bridge the incomplete link between task and learner. It was theorized that in making visual comparisons, haptic individuals encountered difficulty when they were required to retain mentally the images for comparison. What was therefore needed to supplant this image retention was hypothesized to be simultaneous presentation of the images to be compared--that is, presentation via multi-imagery (simultaneous presentation of visual images) rather than linear imagery (sequential presentation of images). It was hypothesized that the simultaneity inherent in multi-imagery would supplant the task requirements of rapid discrimination, assimilation, and mental retention of visual cues, thus completing the learner/task link for haptic individuals. In a linear image presentation, a visual image and its details and relationships would have to be quickly grasped and retained mentally by the learner from image to image. This is a difficult process, especially for haptics, and lack of ability to perform this mental function could be expected to seriously hamper performance on a task which required it. With multiple image presentation, however, there is far less need for mental retention of visual images and details; all necessary for the minimal amount of time required to shift the eyes and attention from image to image. Thus, the task requirement of image retention is almost completely supplanted by the inherent characteristic of the medium of task presentation. This could be expected to be advantageous to all learners in a task requiring visual comparison and location, but it should be of particular benefit to haptic individuals.

This study was designed to investigate a specific application of the supplantation approach to instructional design. It examines the effects of linear and multiple imagery in presenting a task requiring visual comparison and location to individuals of the visual and haptic perceptual types, and attempts to determin whether multiple imager is more effective than linear imagery in a cognitive task involving visual comparisons and whether it is equally effective for learners with two distinctly different cognitive styles. Since it examines hypotheses generated by the application of supplantation principles, the study represents one empirical test of the supplantation approach to instructional design.

Hypotheses

Since the experimental task for the study, a task requiring visual comparison and location, was expected to be made easier by the supplantation provided by multiple imagery, it was expected that, in general, performance on the task in terms of both score and mean latency by both visuals and haptics would be superior with multiple than with linear image presentation. Since the task required visual discrimination, and since supplantation was expected to aid <u>both</u> visuals (i.e., to <u>strengthen</u> the learner/task link) and haptics (i.e., to actually <u>complete</u> the link), it was expected that, overall, visuals would perform better than haptics. Since supplantation of visual image retention was theorized to be more vital for haptics than for visuals, it was expected that haptics would show greater improvement in performance of the experimental task than visuals when multiple imagery was used.

The following were the specific hypotheses tested in the study:

H_1: Visuals make higher scores than haptics on a comparative visual location task.

H_2: Scores are higher on a comparative visual location task with a multiple image presentation than with a linear image presentation.

H_3: There is an ordinal interaction of aptitude and treatment on scores on a comparative visual location task with multiple and linear image presentations.

H_4: Visuals make lower mean latencies than haptics on a comparative visual location task.

H_5: Mean latencies are lower on a comparative visual location task with a multiple image presentation than with a linear image presentation.

H_6: There is an ordinal interaction of aptitude and treatment on mean latencies on a comparative visual location task with multiple and linear presentations.

METHOD

Subjects

The subjects for this study were a group of 200 undergraduate students enrolled in courses in Education at the University of Oklahoma. All subjects were volunteers, ranging in age from 19 to 28 years. While no test was actually given to determine if any of the subjects had visual handicaps, all subjects were questioned concerning such handicaps, and all reported that they had none except those ameliorated by corrective lenses. It was assumed, on this basis, that all subjects were normally sighted or wore optics which gave them normal visual acuity. All subjects who reported that they wore corrective optics were required to wear them during research testing. No consideration was made of the intelligence of the subjects. The investigator found no evidence in the research literature that perceptual type is related to intelligence. In addition, the principle of randomization was built into the research design. Beyond this, however, the effect of intelligence was not considered in this study.

Testing Instruments Used

The 200 subjects were administered a battery of three tests. All the tests were either original tests developed by Lowenfeld (1945) for identifying individuals of visual and haptic perceptual types or variations based on Lowenfeld's tests.

The first test administered to the subjects was Successive Perception Test I. This test (United States Army Air Corps, 1944), which is in motion picture form, was developed by Gibson and associates for use in the World War II Aviation Psychology Program as a part of the pilot selection and training program. Successive Perception Test I is very similar to Lowenfeld's Integration of Successive Impressions (Lowenfeld, 1945). It is based on the same rationale and construct, and is, in fact, a refined version of the Lowenfeld test. The primary distinction between individuals with visual and haptic perception which serves as the basis for both the Lowenfeld test and for Successive Perception Test I is that while visuals have the tendency and ability to integrate partial perceptions into a whole, haptics are satisfied to internalize the separate segments of partial impressions and show neither tendency nor ability to integrate them into whole units.

Successive Perception Test I consists of 38 items: three practice items and 35 actual test items. In each item the subject is shown a pattern, a small section at a time, behind a moving slot. He/she is then shown five similar variants from which he/she must select the one which matches the pattern seen behind the slot. Figure 3 shows an item of the type used in the test. Subjects were asked to indicate their response on each item by circling the appropriate letter on an answer sheet.

Successive Perception Test I was developed originally for use in the Army Air Corps aviation cadet program and had been used extensively in that context. It has also been used several times in educational research dealing with perceptual type and visual aptitude with students ranging from seventh-grade to university level (Erickson, 1966, 1969; Clark, 1971; Bruning, 1974). It was also used in pilot research for the present study (Ausburn, F.B., 1975) as a measure of perceptual type. Bruning (1974) states that

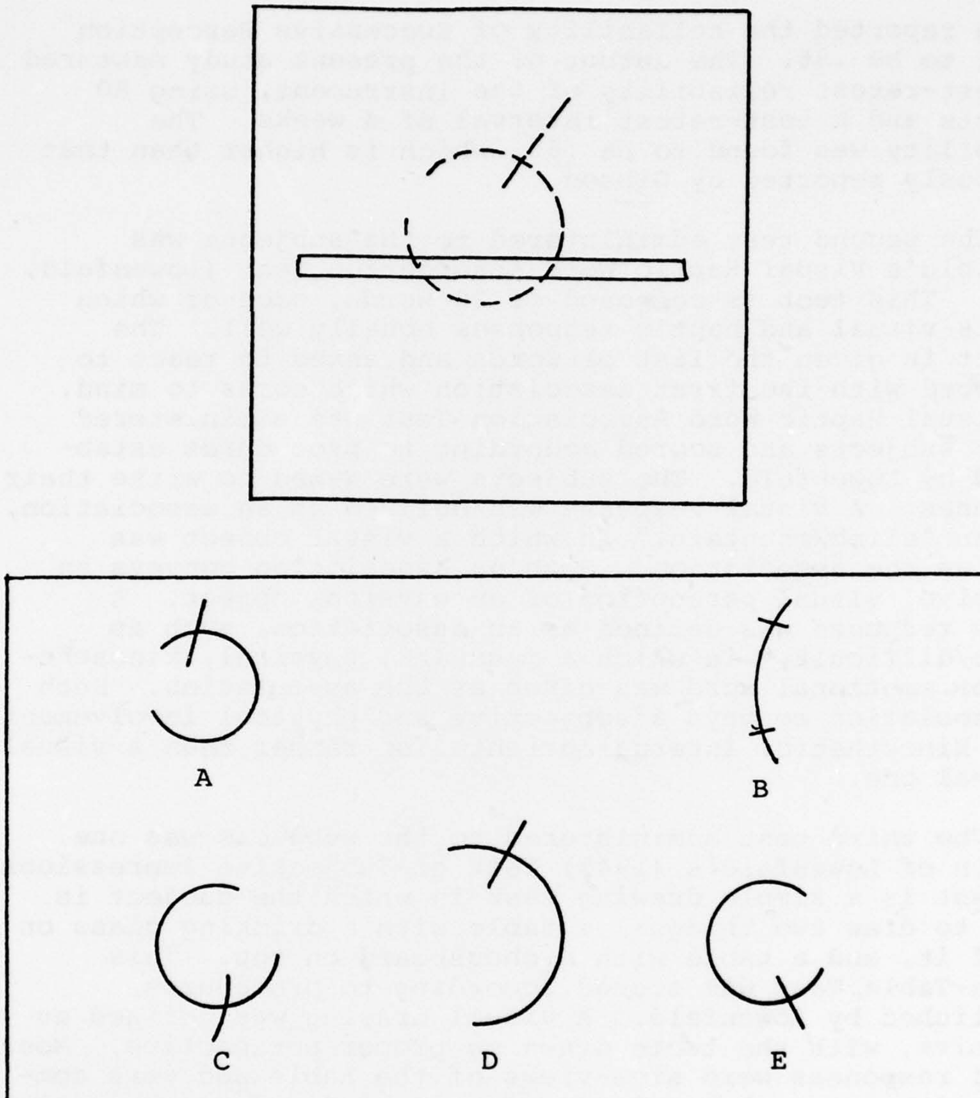

Figure 3.

Sample item of the type used
in Successive Perception Test I

Gibson reported the reliability of Successive Perception Test I to be .56. The author of the present study measured the test-retest reliability of the instrument, using 80 subjects and a test-retest interval of 6 weeks. The reliability was found to be .68, which is higher than that previously reported by Gibson.

The second test administered to the subjects was Lowenfeld's Visual Haptic Word Association Test (Lowenfeld, 1945). This test is composed of 20 words, each of which elicits visual and haptic responses equally well. The subject is given the list of words and asked to react to each word with the first association which comes to mind. The Visual-Haptic Word Association Test was administered to the subjects and scored according to procedures established by Lowenfeld. The subjects were asked to write their responses. A visual response was defined as an association, such as "climb/mountain," in which a visual object was given as the association. Such an association conveys an objective, visual perception of an external object. A haptic response was defined as an association, such as "climb/difficult," in which a muscular, physical, kinesthetic, or emotional word was given as the association. Such an association conveys a subjective and physical involvement and a kinesthetic, internal orientation rather than a visual, external one.

The third test administered to the subjects was one version of Lowenfeld's (1945) Test of Subjective Impressions. The test is a simple drawing task in which the subject is asked to draw two things: a table with a drinking glass on top of it, and a table with a chessboard on top. This Draw-a-Table Test was scored according to procedures established by Lowenfeld. A visual drawing was defined as objective, with the table drawn on proper perspective. Most visual responses were side-views of the table and were complete with legs. A haptic drawing was defined as subjective, with emphasis on the glass or chessboard as if using the item personally. In haptic drawings, perspective was ignored and the subject related himself/herself to the object on the table. Figure 4 shows typical visual and haptic drawings.

Procedures

The subjects were administered all three tests for perceptual type by the same administrator. All three were administered to the subjects in groups, ranging in size from 14 to 22 persons. Successive Perception Test I was

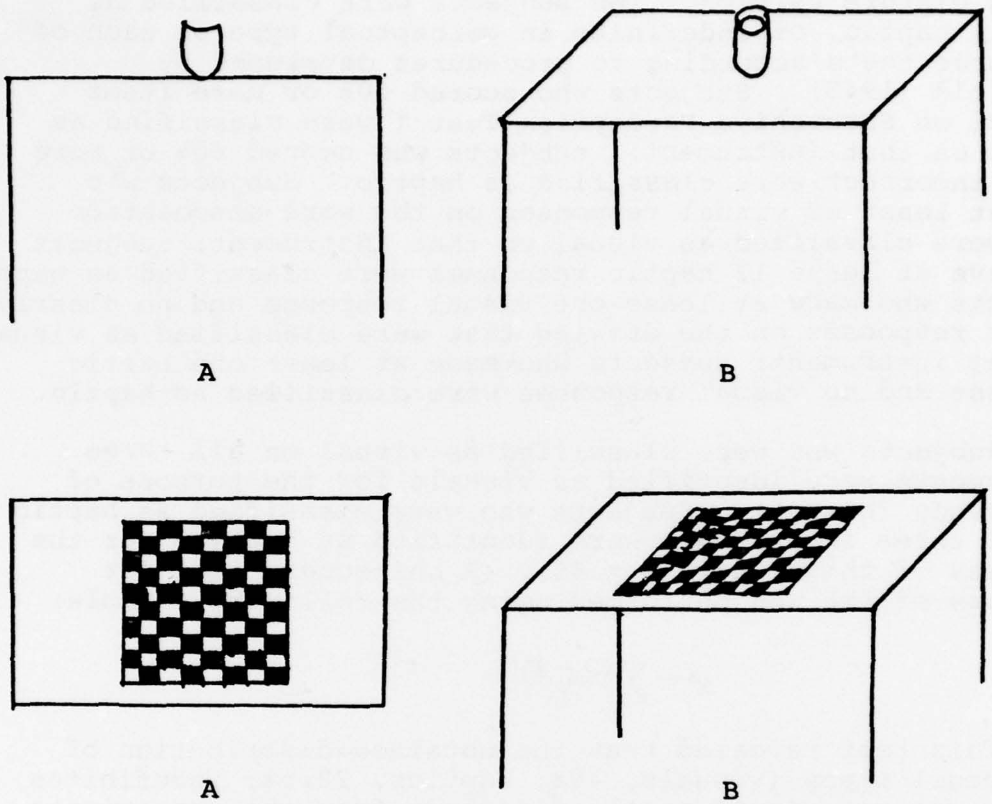

Figure 4.

Examples of typical haptic (A) and visual (B) responses on the drawing task administered via a video tape made from the black-and-white motion picture version. The subjects were classified as visual, haptic, or indefinite in perceptual type on each of the three tests according to procedures developed by Lowenfeld (1945). Subjects who scored 60% or more items correct on Successive Perception Test I were classified as visual on that instrument; subjects who scored 60% or more items incorrect were classified as haptic. Subjects who gave at least 12 visual responses on the word association test were classified as visual on that instrument; subjects who gave at lease 12 haptic responses were classified as haptic. Subjects who made at lease one visual response and no clearly haptic responses on the drawing task were classified as visual on that instrument; subjects who made at least one haptic response and no visual responses were classified as haptic.

Subjects who were classified as visual on all three instruments were identified as visuals for the purpose of this study (N = 96). Subjects who were classified as haptic on all three instruments were identified as haptics for the purposes of this study (N = 45). A chi-square test for goodness-of-fit was performed using the following formula:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

This test revealed that the obtained distribution of perceptual types (visuals, 48%; haptics, 22.5%; indefinites, 29.5%) was not significantly different from the approximate theoretical distribution posited by Lowenfeld (visuals, 50%; haptics, 25%; indefinites, 25%). The results of the chi-square tests are summarized in Table 1.

From the visual and haptic groups, 40 visuals and 40 haptics were selected at random. Each group of 40 was then randomly split into two groups of 20. One group of 20 visuals (ELV) and one group of 20 haptics (ELH) were then randomly selected to receive linear image presentation of the experimental task. The other two groups of 20 visuals (EMV) and 20 haptics (EMH) were designated as the recipients of multiple-image presentation of the experimental task. Figure 5 shows the design of the experiment.

The experimental task for the study was designated as a comparative visual location task. It was designed to test the subjects' ability to view three pictures (35mm color slides) of a complex piece of equipment. These pictures were an extreme close-up, a medium shot, and an overall shot of the entire piece of equipment. The subjects then

TABLE 1

Chi-Square Test for Goodness-of-Fit on Obtained and Expected Distributions of Perceptual Types

Perceptual Type	Expected N	Obtained N
Visual	100	96
Haptic	50	45
Indefinite	50	59
Total N = 200	df = 2	$chi^2 = 2.28$*

* $.50 > p > .30$

	VISUAL	HAPTIC
LINEAR IMAGE PRESENTATION OF TASK	ELV N = 20	ELH N = 20
MULTIPLE IMAGE PRESENTATION OF TASK	EMV N = 20	EMH N = 20

Figure 5. Design for Experimental Procedures

were required to locate on a fourth overall picture a specific criterion item (button, knob, etc.) which had been identified in the first (close-up) pictures with an arrow. The test required the subjects to compare the visual location cues found in each of three pictures in order to make the required location identification response on the fourth picture.

ELV and ELH received a sequential linear presentation of the three stimulus pictures. The pictures were presented as colored 35mm photographic slides. The first slide of each piece of equipment showed a tight closeup of the criterion item on the equipment (button, knob, dial, etc.) which was identified by an arrow. This arrow was present <u>only</u> in this first closeup slide for each item. The second slide showed a medium shot of the equipment, and the third showed an overall shot of the entire piece of equipment. The slides were projected sequentially by a single slide projector. Each slide was displayed on the screen for three seconds. This viewing time is well within the time range which research has established as necessary for the eye fixations necessary for recall of detail in pictorial stimuli (Potter & Levy, 1969; Standing, Conezio, & Haber, 1970). A pilot study (Ausburn, F.B., 1975) also demonstrated this viewing time to be long enough to allow satisfactory performance on the task, but short enough to make the task discriminating. It was therefore retained in the present study.

The total viewing time for each series of slides (each task item) was 9 seconds. The entire experimental task consisted of 16 items, each requiring three separate slides.

After the three slides for each item were viewed by the subject, the projector was turned off, and the subject was given a black-and-white photographic print of the piece of equipment that had been shown in the slides. The subject was asked to point to the criterion item on the equipment which had been identified in the first closeup slide by an arrow.

EMV and EMH recieved a multiple image rather than a linear image presentation of the experimental task. Each subject was shown the same slides that were shown to the subjects in ELV and ELH, but the slides for each task item were presented simultaneously by three separate projectors rather than sequentially by a single projector. All three slides for each task item were shown simultaneously for 9 seconds. After viewing the slides for each item, the subject was given the same photograph used in the linear presentation and asked to point to the criterion item on the equipment.

The total viewing time for the three slides on each item was identical for the linear and multiple image presentations (i.e., 9 seconds). No attempt was made, however, to ascertain if subjects receiving the multi-image presentation spent 3 seconds of viewing time on each of the three slides per item. It was not the purpose of this study to attempt to equate a multiple and linear image presentation on the basis of absolute viewing time spent by a viewer on each single image. It is considered by the author to be an inherent advantage of simultaneous multi-imagery that the viewer is free to selectively deploy attention among the images presented as he or she finds necessary and efficient. Removal of this aspect of multi-imagery is therefore viewed as removal of a characteristic inherent in the medium. Therefore, the only attempt at equating the viewing time for the multiple and linear image presentations of the experimental task in this study was the equating of the <u>total</u> time allowed for viewing <u>all</u> images in each task item.

For all subjects, a record was made of performance on the experimental task. Two performance variables were recorded: the correctness or incorrectness of each location response and the response latency for each item. A total number of correct responses (score) and a mean response latency were then computed and recorded for each subject. These served as the dependent measures in the data analysis.

The analysis of the data obtained was performed in two separate 2 x 2 analyses of variance of completely randomized factorial design. Dependent variables were two measures of performance on the experimental task. One analysis of variance was used to test the hypotheses dealing with scores on the experimental task (H_1, H_2, & H_3). The second analysis of variance was used to test the hypotheses dealing with mean latencies on the task (H_4, H_5, & H_6). Figure 6 shows the statistical design for both analyses of variance.

For both analyses, the independent measures were presentation mode (linear and multiple imagery - Factor A) and perceptual type (visual and haptic - Factor B). There were two levels of each factor. In one analysis, the dependent measure was number of correct responses (score) on the experimental task. For the second analysis, the dependent measure was mean response latency on the task.

RESULTS

<u>Hypotheses Concerning Score on Experimental Task</u>

The following hypotheses concerning scores on the experimental task were tested in the first 2 x 2 analysis of variance:

H_1: Visuals make higher scores than haptics on a comparative visual location task.

H_2: Scores are higher on a comparative visual location task with a multiple image presentation than with a linear image presentation.

H_3: There is an ordinal interaction of aptitude and treatment on scores on a comparative visual location task with mulitple and linear image presentations.

Score was defined as the number of correct responses made by each subject on the experimental task. Table 2 slows the row, column, and cell means on the score variable.

FACTOR A, PRESENTATION MODE	FACTOR B, PERCEPTUAL TYPE Visual (1)	Haptic (2)
	X_{111}	X_{121}
	X_{112}	X_{122}
(1) LINEAR IMAGERY	X_{113}	X_{123}
	.	.
	.	.
	.	.
	X_{1120}	X_{1220}
	X_{211}	X_{221}
	X_{212}	X_{222}
(2) MULTIPLE IMAGERY	X_{213}	X_{223}
	.	.
	.	.
	.	.
	X_{2120}	X_{2220}

Figure 6.

Statistical design for 2 x 2 completely randomized factorial analysis of variance

TABLE 2

Row, Column, and Cell Means on Score Variable

	VISUAL	HAPTIC	
LINEAR IMAGE PRESENTATION	Cell Mean = 13.30	Cell Mean = 9.90	Row Mean = 11.52
MULTIPLE IMAGE PRESENTATION	Cell Mean = 15.30	Cell Mean = 14.00	Row Mean = 14.65
	Column Mean = 14.22	Column Mean = 11.95	

Figure 7 presents the cell means graphically, making the score difference between visuals and haptics and between recipients of multiple and linear image task presentations readily apparent. The analysis of variance showed that these differences are significant beyond the .001 level (F for perceptual type = 53.682; df = 1,79; $p < .001$; F for treatment = 101.287; df = 1,79; $p < .001$). This allows the acceptance of hypotheses 1 and 2. The analysis also showed an interaction of perceptual type and treatment which is significant at the .003 level ($F = 9.859$; df = 1,79; $p = .003$). Examination of Figure 7 shows that this interaction is ordinal in nature, which allows the acceptance of hypothesis 3. Table 3 shows a summary of the analysis of variance.

The presence of a significant interaction in the analysis of variance makes the main effects uninterpretable without the computation of tests for simple main effects, the purpose of which is to test the significance of each factor at each level of the other factor. This is necessary when a significant interaction of factors is present. Thus, in an analysis laid out as follows:

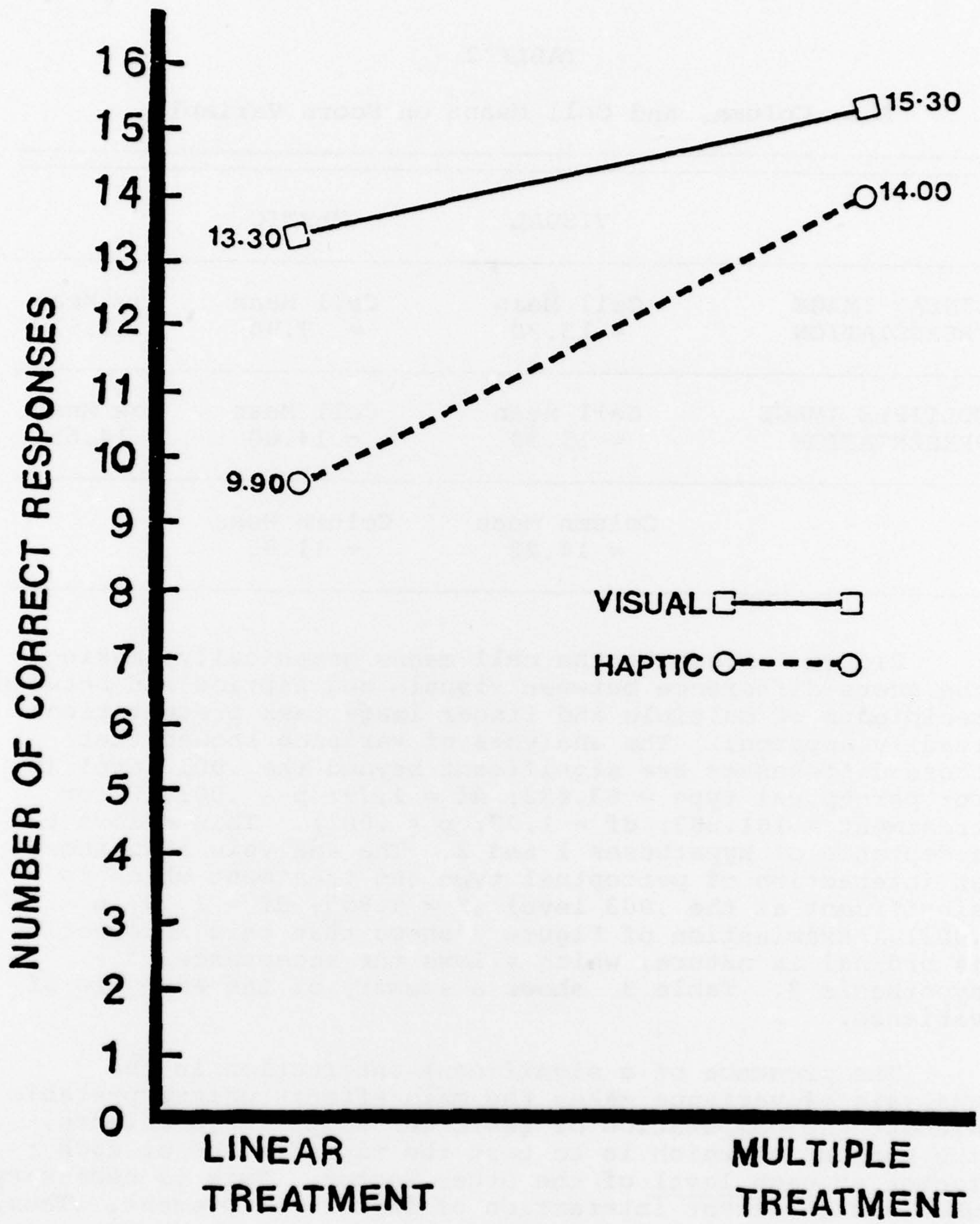

Figure 7.

Graph of cell means on score variable

		B	
		b_1	b_2
A	a_1		
	a_2		

TABLE

Analysis of Variance for Scores on Experimental Task

SOURCE	SS	df	MS	F
Perceptual Type	103.516	1	103.516	53.682*
Treatment	195.313	1	195.313	101.287*
Type X Treatment	19.012	1	19.012	9.859**
Error	145.551	76	1.928	
TOTAL	464.391	79		

* $p < .001$ ** $p = .003$

an analysis of variance tests only the significance of the difference between a_1 and a_2 at <u>both</u> (not each) levels of B and the difference between b_1 and b_2 at <u>both</u> levels of A. Tests for simple main effects test the significance of the difference between each of the following:

a_1 and a_2 at b_1
a_1 and a_2 at b_2
b_1 and b_2 at a_1
b_1 and b_2 at a_2

Using procedures and formulas given by Kirk (1968), tests for simple main effects were computed and then combined with the data from the original analysis of variance to produce the total analysis of variance table shown in Table 4.

TABLE 4

Analysis of Variance for Scores on Experimental Task, Including Tests for Simple Main Effects (Adapted from Kirk, 1968, p. 181)

SOURCE	SS	df	MS	F
A (Row, Treatment)	195.313	1 (p-1)	195.313	101.287*
A at b_1	46.23	1 (p-1)	46.23	23.978*
A at b_2	168.10	1 (p-1)	169.10	87.189*
B (Column, Perceptual Type)	103.516	1 (p-1)	103.516	53.682*
B at a_1	105.63	1 (p-1)	105.63	54.787*
B at a_2	16.90	1 (p-1)	16.90	8.766**
A x B (Interaction)	19.012	1 (p-1) (q-1)	19.012	9.859**
Error	146.551	76 (pq) (n-1)		
TOTAL	464.391	79		

* $p < .001$ ** $p < .005$

Following a procedure recommended by Kirk (1968), the level of significance for each test for simple main effects was established at α/q for Factor A and α/p for Factor B, where

α = overall level of significance for main effects test
q = number of levels of Factor A
p = number of levels of Factor B

The alpha-level selected for the study was .01. Therefore the necessary significance level for each test of simple main effects was equal to .01/2 or .005. Since all tests for simple main effects were significant beyond the .005 level (see Table 4), it was concluded that:

a_1 (linear imagery) is different from a_2 (multiple imagery) at b_1 (visuals)

a_1 (linear imagery) is different from a_2 (multiple imagery) at b_2 (haptics)

b_1 (visual) is different from b_2 (haptic) at a_1 (linear imagery)

b_1 (visual) is different from b_2 (haptic) at a_2 (multiple imagery)

Hypotheses Concerning Mean Latency on Experimental Task

The following hypotheses concerning mean latency on the experimental task were tested in a second 2 x 2 analysis of variance:

H_4: Visuals make lower mean latencies than haptics on a comparative visual location task.

H_5: Mean latencies are lower on a comparative visual location task with a multiple image presentation than with a linear image presentation.

H_6: There is an ordinal interaction of aptitude and treatment on mean latencies on a comparative visual location task with multiple and linear image presentations.

Mean latency for each subject was defined as the mean time (in seconds) to respond on the experimental task. Table 5 shows the row, column, and cell means on the latency variable.

TABLE 5

Row, Column, and Cell Means on Latency Variable

LINEAR IMAGE PRESENTATION	Cell Mean = 3.35	Cell Mean = 5.42	Row Mean = 4.39
MULTIPLE IMAGE PRESENTATION	Cell Mean = 1.82	Cell Mean = 3.15	Row Mean = 2.43

Figure 8 presents the cell means graphically, making the mean latency differences between visuals and haptics and between recipients of multiple and linear image task presentation readily apparent. The analysis of variance showed that these differences are significant beyond the .001 level (F for perceptual type = 26.180; df = 1,79; $p < .001$; F for treatment = 36.958; df = 1,79; $p < .001$).

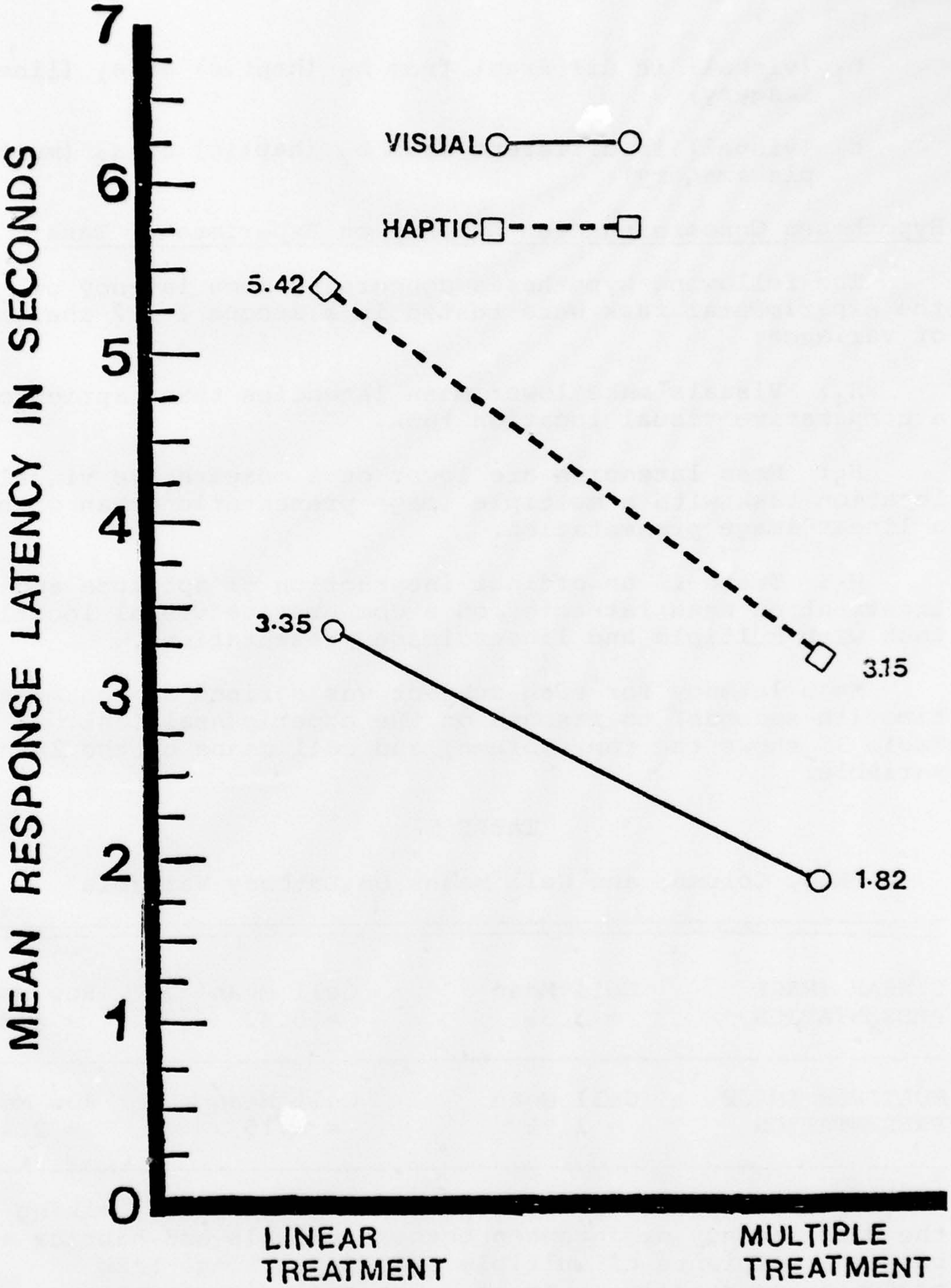

Figure 8.

Graph of cell means on latency variable

This allows the acceptance of hypotheses 4 and 5. The analysis also showed no significant interaction of perceptual type and treatment (F for interaction = 1.719; df = 1,79; p = .19). This calls for the rejection of hypothesis 6. Table 6 shows a summary of the analysis of variance.

TABLE 6

Analysis of Variance
for Mean Latencies on Experimental Task

SOURCE	SS	df	MS	F
Perceptual type	54.291	1	54.291	26.180*
Treatment	76.642	1	76.642	36.958*
Type X Treatment	3.565	1	3.565	1.719**
Error	157.605	76	2.074	
TOTAL	292.102	79		

* $p < .001$ $\quad$ ** $p = .19$

SUMMARY AND DISCUSSION

The study reported here represents an experimental investigation of the relationship between the cognitive style variable of perceptual type and the treatment variable of linear versus multiple imagery on a comparative visual location task. The treatment variables and their hypothesized effect on learning performance were predicted on an application of supplantational instructional design as an alternative to altering cognitive style in a situation in which it interacts unfavorably with a specific learning task. The latter approach has been shown by research efforts to be largely unsuccessful.

A group of 200 undergraduate students were administered a battery of three measures of perceptual type as defined by Lowenfeld's visual-haptic typology. These three measures were Successive Perception Test I, Lowenfeld's Visual-Haptic Word Association Test, and one version of Lowenfeld's Test of Subjective Impressions. Subjects who were identified as visual on all three instruments were classified as visuals for the purposes of this study (N = 96). Subjects who were identified as haptic on all three instruments were classified as haptic for the purposes of this study (N = 45). Forty visuals and forty haptics were selected at random and then randomly assigned to receive linear and multiple image presentations of an experimental task.

The experimental task was designated a comparative visual location task. It involved the viewing of a group of three successively wide-angle photographic slides of a complex piece of equipment and the subsequent utilization of visual location cues to identify the location of a criterion item on a fourth picture. The entire task consisted of 16 such items.

One group of visuals and one group of haptics received a linear image presentation of the task in which the three slides for each task item were presented sequentially by a single projector. The other two groups received a multiple image presentation in which each group of slides were presented simultaneously by three separate projectors. The total viewing time for the three slides of each task item was identical for the linear and multiple image presentations (i.e., 9 seconds).

Two dependent measures were obtained for the experimental task. The two measures were score (defined as the number of correct responses), and mean latency (defined as the mean time to respond). These two measures were analyzed in two separate 2 x 2 factorial analyses of variance. All hypotheses were treated at the .01 level of significance.

The first analysis of variance tested the differences between visuals and haptics and between recipients of linear and multiple image presentations on the score variable. Although significant main effects were found for both perceptual type and image treatment, a significant interaction of the two factors was also found. This made the main effects uninterpretable until tests for simple main effects were computed. After these tests were computed, the following findings were obtained concerning the score variable:

(1) Visuals made higher scores on the comparative visual location task than haptics with linear image treatment.

(2) Visuals made higher scores than haptics with multiple image treatment.

(3) Visuals made higher scores on the task with multiple image treatment than with linear image treatment.

(4) Haptics made higher scores on the task with multiple-image treatment than with linear treatment.

(5) There was an ordinal interaction of perceptual type and image treatment on the scores on the task.

An examination of the graph of the cell means on the score variable (see Figure 7) indicates that the interaction of perceptual types and image treatment is ordinal in nature rather than disordinal; that is, the graph lines do not cross. The interaction was therefore interpreted as an indication that both visuals and haptics benefited from the supplantation provided by multiple-image task presentation. Both perceptual types made higher scores on the experimental task with multiple image presentation than with linear image presentation. Visuals therefore obtained higher scores than haptics with both presentation treatments. Haptics, however, benefited more than visuals from multiple image presentations, as indicated by the steeper rise in the graph line for haptics. This fact accounts for the significant interaction found in the analysis of variance. It also bears out predictions which stem from supplantation provided by multiple imagery: it was the haptic who needed it most--to actually complete the learner/task link rather than merely strengthen it--and who therefore benefited most from it.

A second 2 x 2 factorial analysis of variance tested the differences between visuals and haptics and between recipients of linear and multiple-image presentations on the mean latency variable. This analysis produced significant main effects on both perceptual type and image treatment but no significant interaction. The following findings were obtained:

(1) Visuals made lower mean latencies than haptics on the comparative visual location task.

(2) Mean latencies were lower on the task with multiple image treatment than with linear image treatment.

(3) There was no interaction of perceptual type and image treatment on mean latencies on the task. While the interaction found was in the direction predicted from supplantation theory, it was not statistically significant.

Although generalization of the findings of the present study is limited by the nature of the sample used, three major conclusions emerge from the findings:

(1) As predicted from Lowenfeld's definition of the characteristics of visual and haptic perceptual types, visuals perform better than haptics on a comparative visual location task such as the experimental task used in this study. They perform better in terms of both score and latency; that is, they give more correct responses and do so more quickly than haptics.

(2) As predicted from application of supplantation theory and the concept of a learner/task link, performance is better on this type of task when simultaneous multiple imagery is used than when sequential linear imagery is used. Superior performance occurs on both score and latency variables; that is, more correct responses are given, and given more quickly, with multiple imagery than with linear imagery.

(3) As predicted from supplantation theory, although both visuals and haptics perform better with multiple than with linear imagery, haptics show the greater benefit, especially on the score variable. This lends support to the concept that while the supplantation provided by the multi-image treatment of a necessary task requirement (image retention) <u>strengthened</u> the learner/task link for visuals, thus improving their performance somewhat, it actually <u>completed</u> the link for haptics, for whom the supplantation was more vital, and thus improved their performance to a considerably greater degree.

The study reported here represents a single empirical test of a supplantation approach to designing instructional treatments in cases where discrepancies exist between learner capabilities dictated by their cognitive style and capabilities demanded by a learning task. This type of instructional design is viewed as an alternative to attempting to alter cognitive style, which has been shown to be highly resistant to long-term, generalizable change. While the supplantational design undertaken in this study was successful and therefore supportive of the supplantation model, further studies may indicate that it should be modified or abandoned altogether. Only if it continues to provide a basis for the development of instructional treatments which produce predictable and successful performance in specific learner characteristic/task requirement situations will it be a viable tool for instructional design.

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